pear altogether, or are transformed into others of a different colour; and, lastly, the germinal vesicle is destroyed.

By tracing the changes of the ovule in unfecundated females of the same species, the author finds the disappearance of the vitelline granules to be dependent upon, while the formation of the chorion is wholly independent of, the influence exerted by the spermatic particles on the ovule.

As soon as the vitelline granules and germinal vesicle have disappeared, the whole interior of the chorion is filled with a clear fluid, in which a few granules and the germinal spot are seen to remain. By swelling up this constitutes the embryonic vesicle and spot. A membrane separates from the interior of the chorion, and contracting on the granules forms a spherical yolk, in the centre of which is the embryonic vesicle. This is the perfect ovum. The subsequent divisions of the embryonic spot, vesicle and yolk are described; the author particularly pointing out the gyrations of the embryonic vesicle immediately after division. As soon as the whole interior of the egg has been filled by the subdivisions of the yolk, the external granules coalesce and form a continuous membrane internal to the chorion, which by gradual depression on one of its sides forms first a fleshy cup, and then, as the membrane of its concavity touches that of its convex surface, acquires the form of a ring. The ring divides at some point of its circumference, the extremities become pointed, and thus the young Ascaris receives its characteristic shape. The author has frequently repeated his observations with a view to their verification, and has employed the camera lucida to render the illustrative figures as accurate as possible.

9. "On Induced and other Magnetic Forces." By Sir W. Snow Harris, F.R.S. &c. Received April 29, 1851.

The question as to identity in the source of those several and mysterious powers of nature by which masses or particles are moved either toward, or from each other, being a question of deep physical interest, the author of this paper has been led to some further investigation of the nature and laws of magnetic force, in the course of which several new facts have presented themselves which he thinks not altogether unworthy of attention.

Magnetic attraction as commonly observed being found to depend on certain impressions made on the attracting bodies usually designated by the general term induction, it appears essential to the progress of any inquiry into the laws of those forces operating externally to a magnet through space, to commence with a rigid examination of the nature and mode of action of those inductive forces upon which the reciprocal force of attraction between the bodies immediately depends. These forces of induction may be considered as a series of successive or reverberating influences, operating between the near and opposed surfaces of the magnetic bodies. When, for example, a magnet is opposed to a mass of soft iron, a direct impression is first made on the iron by which the iron is rendered temporarily magnetic; this induced force operates in its turn by a

species of reverberation or reflexion upon the near pole of the magnet, and calls into play a portion of the magnetic force in the direction of the iron, which was previously operating toward the centre of the magnet; this action being once set up, may continue for a series of waves reverberating between the opposed surfaces, until the action sinks away as it were into rest. The author examines experimentally, by means of instruments, the principles of which he has already detailed in the Transactions of the Royal Society, this peculiar kind of action, and arrives at the following deductions relative to the laws of magnetic induction.

A limit exists in respect of induced magnetic force, different for different magnets, and varying with the magnetic conditions of the experiment, toward which the increments in the force continually approach, as if the opposed bodies were only susceptible of a given amount of induction under the existing circumstances.

Taking the force toward the limit of action, the amount of induction is in some inverse ratio greater than that of the simple distance; it was not however in any case found to exceed the inverse sesquiplicate ratio or $\frac{3}{2}$ power of the distance; as the distance is diminished the induction is as the distance inversely, but may in the mean time be as the $\frac{4}{3}$ or $\frac{5}{4}$ powers of the distances inversely, or near those powers. On further diminishing the distance, the induction was found in certain cases to be as the $\frac{2}{3}$ and $\frac{1}{2}$ powers of the distances, thus causing a series of changes in the law of magnetic attraction as commonly observed, which have hitherto greatly embarrassed the views of philosophers in their inquiries into this species of force. When the convergence is slow the induced force may not for a long series of terms appear to change, but when from any circumstance the convergence is accelerated, then the changes become more marked and successive. As a general result, however, the author is led to conclude, that magnetic induction is as the magnetic intensity directly, and from the $\frac{1}{2}$ to the $\frac{3}{2}$ power of the distance inversely.

In the course of these inquiries, it was found that the inductive action depended, not on the mass, but on the surface of the magnetic substance, and that magnetism, like electricity, exhibits a decrease of intensity when the surface of the iron upon which it is disposed is extended. A hollow cylinder of soft iron was carefully prepared in a lathe, and fitted with a solid interior core capable of being drawn out from within the cylinder; this compound body was exposed to the inductive action of a powerful magnetic bar, and the induced force estimated by the reciprocal force of attraction exerted between the mass and a cylinder of soft iron suspended from the author's magnetic balance, or from one arm of a light beam, set up in the way of a common balance. The degree of force being observed, the solid core was drawn out so as to extend the surface of the mass under induction. The intensity immediately declined, and again increased on replacing the solid within the hollow cylinder, being a result of exactly the same character as that produced by the extension of an electrified surface. When the interior solid

core was removed altogether, then the induced force remained unchanged, it being precisely the same whether the body were taken hollow or solid. In accordance with this result, hollow cylindrical magnets were found as susceptible of magnetic power as solid masses of the same temperament and dimensions; an unmagnetized solid and tempered steel cylinder, placed within a hollow tempered steel cylinder, does not become magnetic on touching the external cylinder in the usual way. The magnetism, however, of a hollow cylindrical magnet is partially destroyed by placing within it a cylinder of soft iron, or the reverse poles of another magnet; nor can a hollow cylinder of tempered steel having a solid core of soft iron be rendered magnetic by the usual methods of touch. These results, it is considered, supply the experiments thought by Mr. Barlow so desirable to confirm his deductions relative to the action of iron shells and balls on the compass needle, which he found to be as the $\frac{3}{2}$ power of the surface, whatever the weight and thickness of the iron.

The author now proceeds to notice the investigations of Hawksbee, Brook Taylor, Muschenbroek and others, and thinks the inquiries of these philosophers have not been sufficiently considered or appreciated; that instead of the results exhibiting anomalies and discrepancies, they are really necessary consequences of the more elementary laws of induction, and perfectly explicable upon the fundamental principles of magnetism. He endeavours to show, that by the changes in the law of the induction, as already stated, laws of force will arise perfectly coincident with the results arrived at by Hawksbee, Brook Taylor and others; that is to say, the law of force may appear to be as the $\frac{5}{2}$ power of the distance inversely, as found by Brook Taylor; or as the $\frac{3}{2}$ power inversely, as found by Martin; or in the inverse duplicate ratio of the distance, as observed by Lambert; or as the simple distance inversely, as determined by Muschenbroek in several cases; or it may be as the cubes of the distances inversely, as stated by Newton. Examples are given in which these several laws were found to obtain.

In examining the laws of magnetic repulsion, similar results are arrived at. The inductive forces here, however, are subversive of the existing polar arrangements; hence the apparent repulsion: so long as the existing magnetic polarities remain unchanged, the law of force will be generally as the second power of the distance inversely; when the distances are small, it will be inversely as the simple distance; when the inductive actions subvert the existing polarities, then the law of force appears irregular and subject to no regular variation, as observed in all the early experiments with repellent poles.

The author is led to conclude, that the apparent law of attractive force will be found to depend in certain cases on the distances at which the force operates, as referred to the total distance or limit of action. Taken between $\frac{2}{5}$ths and $\frac{5}{6}$ths of the limit of action, the force may be inversely as the third powers or cubes of the distances; taken between $\frac{2}{5}$ths and $\frac{3}{5}$ths of the limit of action, it may be in the

inverse sesquiduplicate ratio, or $\frac{5}{2}$ power of the distances; between $\frac{1}{3}$rd and $\frac{3}{5}$ths as the squares of the distances inversely. From the $\frac{1}{5}$th to $\frac{1}{2}$ of the limit of action it may be as the $\frac{3}{2}$ power of the distance inversely; within less than $\frac{1}{5}$th, it will be generally as the simple distance inversely.

On a further review of these laws of magnetism, it is evident that the immediate effect of an increase or decrease of distance, is an increase or decrease of the effective magnetism on which the total or reciprocal force depends. Thus taking the cases just quoted, it will be seen that the total force is always as the square of the induction, whatever be the resulting law of the attraction. Hence the force may as well be taken as the square of the quantity of effective magnetism directly, as some power of the distance inversely.

The author admits the difficulty in the way of the employment of such terms as quantity of magnetism, magnetic charge, and the like, and therefore only employs them according to the common acceptation of such terms, and not as referring to any particular hypothesis: he thinks there must necessarily be in such inquiries an element fairly enough expressed by the general term quantity as expressive of the relative or absolute magnitude of the cause, whatever it be, upon which the observed effects depend, and thinks it so far essential to obtain exact quantitative measures. In electricity we may estimate the charge conveyed into a battery by means of the unit measure, and we can at pleasure operate with one-half, one-third, &c. the quantity of electricity numerically expressed; but we have as yet no such measure in magnetism, and we are quite uncertain as to the quantity of effective magnetism in operation. The author hence endeavours to verify the law of magnetic charge just mentioned by a direct quantitative experimental process. A cylindrical rod of soft iron being surrounded by three successive coils of covered copper wire, was placed under the trial cylinder of the magnetometer and exposed to the operation of one or more precisely equal and similar batteries; one coil being appropriated to each battery. It is inferred that if one battery and one coil produced one measure of magnetism, two batteries and two coils would develope two measures, and so on; so that we should have only to determine the attractive force under this condition; now the attractive forces were found to be as the square of the number of batteries in action upon this cylinder, that is to say, as the square of the magnetism induced in the iron; hence the quantity of magnetism is as the square roots of the reciprocal forces. If therefore the reciprocal force between a magnet A and a cylinder of soft iron taken at a constant distance were represented by an equivalent of 4 grains, whilst the similar force with a magnet B at the same distance were represented by 9 grains, then the effective quantities of magnetism and operation in each case would be as $\sqrt{4} : \sqrt{9}$, that is as $2 : 3$.

Availing himself of this law, the author endeavours to deduce experimentally the magnetic development in different points of a regularly tempered and magnetized bar, taken between the magnetic centre and extremities; and he finds by a very careful manipulation,

that the magnetism in these points is directly as the distance from the magnetic centre; the reciprocal force on a small trial cylinder being as the squares of the distances from the centre.

Some striking analogies in the state of a magnetized steel bar and the common Leyden jar are noticed in this communication, from which it would appear that the conditions of electrical and magnetic force are precisely the same, and from which the author concludes that magnetic attraction is reducible, as in electricity, to an action between opposed surfaces; he thinks that a predisposition to identify these forces with that of gravity and other central forces has led many profound mathematicians and philosophers to question unduly the accuracy of every result not in accordance with such a deduction. He observes that Sir Isaac Newton considered "that the virtue of the magnet is contracted to the interposition of an iron plate, and is almost terminated by it, for bodies further off are not attracted by the magnet so much as by the iron plate*;" as also that this power is essentially different from gravity, "and in receding from the magnet decreases not in the duplicate, but almost in the triplicate proportion of the distance*," a result which has been shown to be perfectly consistent with experiments. Newton however has been supposed to have had "very inaccurate ideas of magnetic phenomena†;" it would be very difficult however to show from the little which this great author has advanced upon this subject in his grand work, the Principia, in what his views of magnetic action were defective; they appear on the contrary to be in most perfect accordance with experimental facts. In associating magnetic action with a law of the "centrifugal forces of particles terminating in particles next them," Newton never pretended to offer any theory of magnetism, but says with his usual diffidence, "whether elastic fluids do really consist of particles so repelling each other is a physical question," and "which he leaves philosophers to determine." On the other hand, a large amount of experimental research by Hawksbee, Brook Taylor, Whiston, Muschenbroek, and other eminent men, has been supposed by Dr. Robison as unworthy of confidence, and ill adapted to the object for which it was designed‡. The same learned writer thinks that magnetic attractions and repulsions are not the "proper phenomena for declaring the precise law of variation." Yet was it by these same attractions and repulsions that Lambert, and more especially Coulomb, deduced what this accomplished author considers as being the true law of force. The author of this communication is led to believe, that all the results of these inquiries, including the deduction of Newton, are not only consistent with, but necessary consequences of, the laws of induced magnetic forces, as he has endeavoured to prove, and that the action of magnetism as commonly observed is something different from what has been usually imagined. That future inquiries may lead to the identity in origin of magnetic and gravitating force he thinks not improbable; there may be some diffuse emanation through space, the

* Principia, Books 2 and 3. † Edinb. Ency. vol. xiii. p. 270.
‡ Mechanical Philosophy, vol. iv. p. 217.

source of gravity, and other central forces; and it is not impossible but that the relations of this medium to the particles of common matter may admit of considerable modification or change, and which may be the source of that peculiar power we find displayed in those bodies we consider as being magnetic and call magnets. It has been occasionally supposed that in the reciprocal force between magnets and iron there is a peculiar agency in operation, the law of which is disturbed by the new forces of induction liable to ensue in changing the distances. The author however is of opinion that such a notion is inconsistent with the course of nature; it is induction which constitutes magnetic action, there is no other form of action; when induction is not present there is in fact no action; we must hence look to these very changes for an explanation of variable magnetic force.

10. "Researches into the Identity of the Existences or Forces, Light, Heat, Electricity and Magnetism." By John Goodman, M.D. Communicated by Thomas Bell, Esq., Sec. R.S. &c. Received March 7, 1851.

In this communication the author describes the effects that were produced on a moderately sensitive galvanometer by exposure to the sun's rays, and which were observed by him during a period of four months, commencing on the 14th of November, 1850. The instrument is described as consisting of forty-six turns of covered copper wire, $\frac{1}{25}$th of an inch in diameter. The helix is blackened with ink at its southern extremity, and has a single magnetized sewing-needle suspended by about sixteen inches of silken fibre in its centre. The dial, which is of card-board, and divided into the usual number of degrees, rests upon the upper surface of the helix, and shades it from the ordinary light or sun's rays, except at its extremities, and occasionally some portions of the lower bundle of wires; and when the sun is very low the rays may be seen also to illumine to some extent the surface of the upper bundle. The indicator is formed of a slender filament of light wood in the usual manner, and the whole is enclosed in a glass shade. This instrument was placed for experiment in a window having a southern aspect; and whilst the sun was strongly shining upon it, it was frequently observed that there could not be obtained, either on account of vibrations or the erroneous condition of the instrument, any true indications. On shading the instrument from the sun's rays by a screen, the vibrations ceased, and the needle again adjusted itself north and south.

On removing the screen the needle began again to vibrate, and was soon discovered to become stationary at some distance from zero, indicating the transmission of a current in the helix. This deflection of the needle was soon found to be always, under the same circumstances, in the same direction, and to give indications of a current corresponding to the brightness of the sun.

This action appeared to depend upon the incidence of the sun's rays upon the south extremity, and some of the lower or upper bundle of wires only of the helix; for when they began to illumine